Segway® Robotic Mobility Platform
User Guide

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How to use this guide

This guide is provided with Segway Robotic Mobility Platforms (RMP) to aid users in understanding and integrating the Segway RMP into their application.

- Read this entire guide before turning on the RMP. Users of the RMP100 and RMP200 should pay particular attention to "Theory of Operation: Balancing Dynamics".

- Study and understand the section describing the Emergency Stop (E-stop) and Safety Shutdown functions.

- Browse the "Segway Robotic Mobility Platform Interface Guide" to understand the control and command architecture of the RMP.

- Install the appropriate USB Driver software before connecting the RMP to a PC via USB.

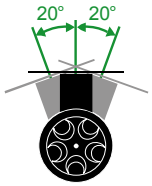
⚠ WARNING

Risk of Death or Serious Injury

The Segway RMP is a powerful machine – its motors can produce over 2 hp under certain transient conditions. Read and fully understand the material in this guide before attempting to use the RMP.

Do not sit, stand, or ride on the RMP

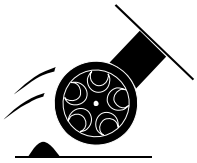
Do not drive the RMP at people or animals



Only enable the balance controller when the platform is free to tilt [-20,20] degrees.

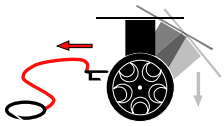
Do not lift the RMP off the ground when it is balancing – the control system will spin the wheels in an attempt to stay balanced.

Do not lift the RMP by the wheels – your hands may get pinched if the frame rotates



Avoid slippery surfaces, loose materials, or any other surface that does not provide good traction. Avoid obstacles and any terrain feature that could interfere with wheel movement.

Disabling the balance controller will cause the RMP to fall over – A falling RMP could strike persons or objects nearby.



Pulling the E-Stop Lanyard will cause the RMP to fall over – A falling RMP could strike persons or objects nearby.

Do not enter balance mode without the frame attached.

Alert people in the vicinity when RMP operation is commencing.

Introduction

Segway Inc. provides these instructions for users of the Segway™ Robotic Mobility Platform (RMP). These instructions and the Segway RMP are designed for use by research scientists and engineers who are experienced with tele-operated and autonomous robots and their safe use. Persons who lack that experience should not attempt to use the Segway RMP.

The Segway RMP is based on the design of the Segway Human Transporter (HT). The RMP is a transportation platform designed for integration into a system that has a "control processor." The control, or host processor must create velocity and steering commands and output these in the correct message format to the RMP. The control processor may communicate with the RMP using either CAN bus or USB. The document "Segway Robotic Mobility Platform Interface Guide" is essential to understanding communication between the control processor and the RMP. The control processor may be a laptop receiving joystick commands from a stationary PC, a small microcontroller (e.g. a Microchip PIC processor), or some other device that can send velocity and steering commands to the RMP via USB or CAN bus.

The system designer is responsible for implementing appropriate safety systems to prevent damage and/or injury. The system designer must understand the operation of the RMP and anticipate hazards that may result from loss of control or interaction with the environment. The Segway RMP provides both a control command and an emergency stop switch that can stop its forward movement in an emergency.

Use of the Segway RMP involves risk. If an RMP tire loses traction or runs into an obstacle, the Segway RMP can fall over. If the RMP experiences an internal malfunction, the RMP may fall over. If possible, the Segway RMP will perform a "Safety Shutdown" and automatically come to a stop in the event of fully discharged battery packs or certain failures in the balancing system. (After 10 seconds of audible warning, the RMP will shutdown - if the RMP is in "Balance Mode", it will fall over.) The Segway RMP does not dynamically balance laterally, so cornering at too great a speed or traversing a slope can cause the Segway RMP to tip over sideways. The Segway RMP is equipped with an E-stop tether. Pulling the tether will disable all motor power. In each of these cases, the Segway RMP could cause injury to nearby person(s) or damage to property situated on or near the Segway RMP. Careful use of the Segway RMP reduces, but does not eliminate this risk. This risk may be further reduced by using the Segway RMP in "Tractor Mode" and attaching additional ground contacting supports (e.g. casters) as described in the Tractor Mode section of these instructions.

The Segway RMP should not be used to transport any person. Persons should not sit, stand, or in any way attempt to ride on the Segway RMP.

Read and understand these instructions thoroughly before attempting to use the Segway RMP. Retain this document for future reference.

Segway Robotic Mobility Platform Models

This guide is intended to help you setup and properly use the Segway RMP. There are five RMP models, three balancing models (RMP100, RMP200 and RMP200ATV) and two non-balancing models (RMP50 and RMP400).

Balancing RMP Models

RMP 200

RMP 100

RMP 100: based on the p series Segway Human Transporter (HT).
RMP 200: based on the i Series Segway HT.
RMP 200ATV: based on the Offroad Series Segway XT.

Operation of these three models is nearly identical except for payload and terrain capabilities. The RMP 100 has been tuned to handle lighter payloads and is more suitable for flat surfaces. The RMP 200 has larger wheels and stronger motors to handle more challenging terrain and larger payloads. The RMP200ATV is configured lithium batteries and all-terrain tires to enable the highest level of terrain and payload capability.

Balancing RMP models have two operating modes: “Tractor Mode” and “Balance Mode”.

Tractor Mode provides statically stable operation, with a larger footprint and lower payload height. The limits of stability are defined by the distribution of the contact points and the height of the center of gravity.

Balance Mode provides dynamically stable operation with a smaller footprint and higher payload height. This has the benefit of allowing for a much higher center of gravity while still maintaining a small footprint.

Statically Stable RMP Models

RMP 400

RMP 50

RMP 400: based on the Segway XT.
RMP 50: based on the p series Segway HT.

The RMP400 and RMP50 have only one operating mode: "Tractor Mode"

Tractor Mode provides statically stable operation, with a larger footprint and lower payload height. The limits of stability are defined by the distribution of the contact points and the height of the center of gravity.

Operator Supplied Equipment

The velocity and turn rate of the RMP are controlled via USB or Controller Area Network (CAN) bus commands. These may be generated using a dedicated microcontroller, a PC system or other computer based system to initiate commands. The user must provide a computer system and write an application to communicate with the RMP.

The “Segway Robotic Mobility Platform Interface Guide” provides detailed information about the communications interface. The information contained in the interface guide will be necessary to control the RMP with a device other than the demonstration system.

RMP Specifications

Command Interface	All Models
Communications Link	USB external, CAN available via internal connector
Control	Industrial pushbutton interface for power and mode select
Data Update Rate	100 Hz
RMP firmware	Programmed at assembly
Demo software	Windows 2000 executable and source code provided

Performance	RMP200	RMP200 ATV	RMP100	RMP50	RMP400
Top Speed	10 mph (16 kph)	10 mph (16 kph)	6 mph (10 kph)	4 mph (6 kph)	18 mph (29 kph)
Payload	100 lbs (45 kg)	150 lbs (67 kg)	100 lbs (45 kg)	50 lbs (45 kg)	200 lbs (90 kg)
Turning Radius	Zero				Zero *(load dependent)*
Turning Envelope	30 in (76 cm)	34 in (86 cm)	24 in (61 cm)	25 in (64 cm)	50 in (127 cm)
Maximum Climbing and Descending Capability (traction limited)	10 degrees		5 degrees	0 degrees	45 degrees
Controller modes	Dynamically stabilized and statically stable controller modes			Statically stable control mode ONLY	

Batteries	RMP200	RMP200 ATV	RMP100	RMP50	RMP400
Battery Chemistry	NiMH	Li	NiMH	NiMH	Li
Acceptable line current for charger:	90 to 260 Volts; 50 to 60 Hz				
Charge Rate (72 Volt nominal)	600 milliamps per battery				
Battery Life (Full Charge / Discharge Cycles)	300 to 500				
Operating Temperature Range (NiMH)	32°F to 122°F (0°C to 50°C)				
Operating Temperature Range (Li)	14°F to 122°F (-10°C to 50°C)				
Charging Temperature Range (NiMH)	41°F to 77°F (5°C to 25°C)				
Charging Temperature Range (Li)	14°F to 122°F (-10°C to 50°C)				
Battery Weight (total)	19 lbs (8.6 kg)	23 lbs (10.3 kg)	15 lbs (6.8 kg)	7.5 lbs (3.4 kg)	46 lbs (20.6 kg)

Range and Energy	RMP200	RMP200 ATV	RMP100	RMP50	RMP400
Range under Optimal Test conditions	15 mi (24 km)	15 mi (24 km)	12 mi (19km)	6 mi (10 km)	15 mi (24 km)
Range under Good conditions	12 mi (19km)	12 mi (19km)	8 mi (13 km)	4 mi (6 km)	12 mi (19km)
Range under Severe conditions	8 mi (13 km)	8 mi (13 km)	4 mi (6 km)	2 mi (3 km)	6 mi (10 km)
Run time, stationary	8 hours				
Recharge Time (from empty)	~6 hours	~8 hours	~4 hours	~4 hours	~8 hours

Environmental Capabilities	All Models
Storage & Transport Temperature (no damage to machine, <1 month)	-20°C to +50°C (-4°F to +122°F)
Storage Temperature (for normal charging and operation)	+15°C to +35°C (+59°F to +95°F)
Humidity Range	0 to 95% RH (Storage); 5% to 95% RH (Operational)
Altitude Range (storage)	Sea Level to 40,000 ft. (12,000 m)
Altitude Range (operation)	Sea Level to 12,000 ft (3,700 m)

Dimensions	RMP200	RMP200 ATV	RMP100	RMP50	RMP400
Overall width	25 in (63 cm)	31 in (79 cm)	21.8 in (56 cm)	21.8 in (56 cm)	31 in (79 cm)
Overall height	29.5 in (75 cm)	30.5 in (78 cm)	27 in (69 cm)	27 in (69 cm)	21 in (53 cm)
Overall length	19 in (48 cm)	21 in (53 cm)	16 in (41 cm)	16 in (41 cm)	43.5 in (111 cm)
Weight	140 lb (64 kg)	160 lb (73 kg)	125 lb (57 kg)	60 lb (27 kg)	220 lb (100 kg)
Equipment mounting	Multiple mounting bosses on top plate and side support				
Propulsion System					
Motor Torque Constant @ motor shaft	0.071 Nm/amp	0.071 Nm/amp	0.054 Nm/amp	0.054 Nm/amp	0.071 Nm/amp
Motor Drive Peak Current, per wheel	70 amp			35 amp	70 amp
Motor Drive Continuous Current, per wheel	24 amp			12 amp	24 amp
Gearbox Ratio	24:1				
Battery Pack Capacity (total)	380 watt-hours	800 watt-hours	290 watt-hours	145 watt-hours	1600 watt-hours
Battery Pack Voltage (nominal)	72 volts		56 volts	56 volts	72 volts
Tire Diameter	19 in (48 cm)	21 in (53 cm)	16 in (41 cm)	16 in (41 cm)	21 in (53cm)
Wheel Track Width	21 in (53 cm)	24.5 in (62 cm)	18 in (46 cm)	18 in (46 cm)	24.5 in (62 cm)

Limited Warranty	All Models
All parts & components	90 days

Assembly

All Segway Robotic Mobility Platform models may be assembled with basic hand tools. Using a quality torque wrench is the best way to avoid stripped or broken fasteners, stripped threads, and fasteners that vibrate loose. All fasteners should be checked periodically for tightness. The RMP powerbase must be securely supported to prevent tipping before you begin assembling the RMP frame.

RMP100 and RMP200

The RMP Top Plate weighs approximately 30 lbs (13.6 kg) and the RMP Ballast Plate weighs 25 lbs (11.3 kg). Use an assistant if necessary to maneuver these plates to avoid dropping them or pinching fingers. Exploded drawings of the various RMP frames are contained at the end of this section.

Minimum Tools needed for assembly:

- 5mm Hex wrench
- 8mm Hex wrench

Recommended tools for easiest assembly:

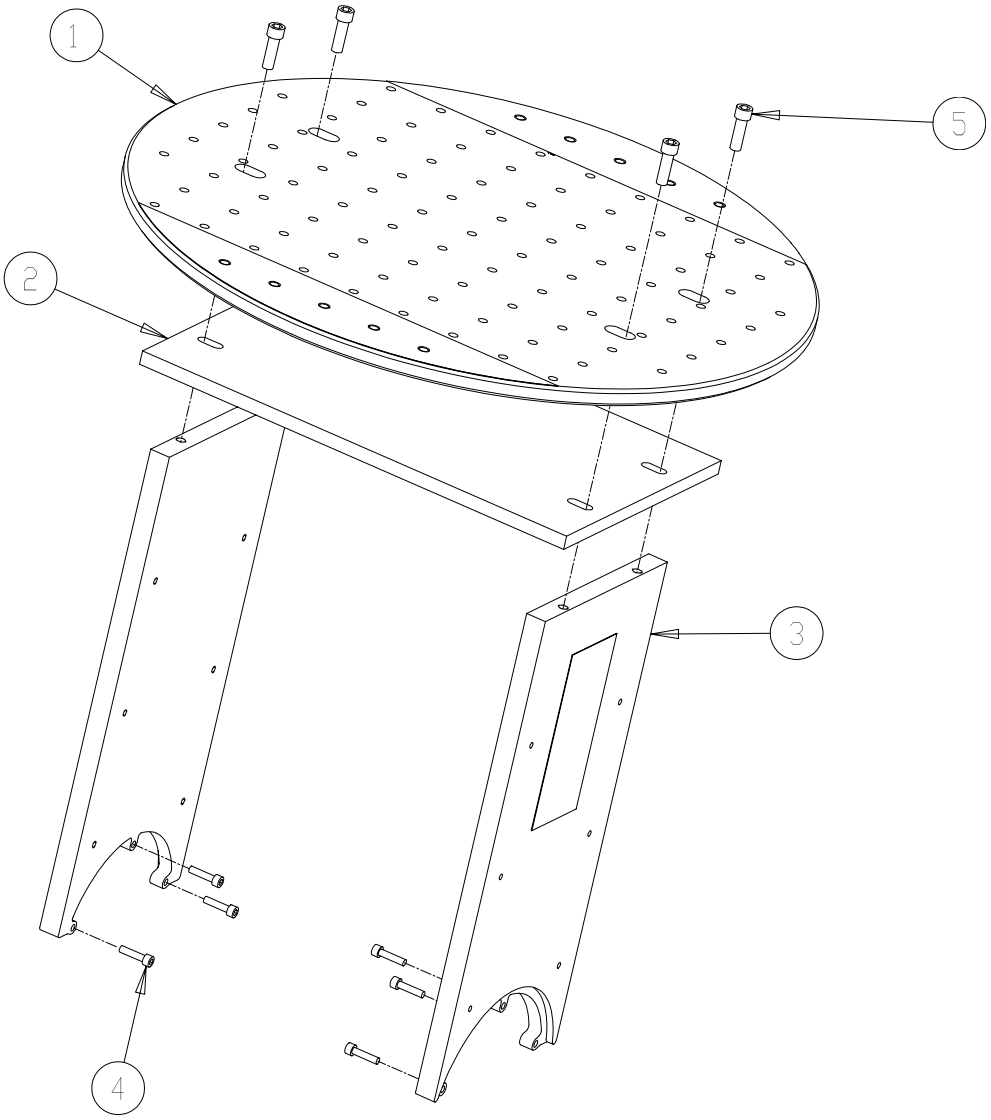
- Torque wrench, 3/8 drive
- 5mm Hex bit socket, 3/8 drive
- 8mm Hex bit socket, 3/8 drive

Refer to the exploded view drawing below and begin by assembling the Vertical Plates (3) to the inside of the gearboxes. Use M6 screws (4) to fasten the Vertical Plates to the gearboxes. Do no tighten fully at this time.

If using the Ballast Plate, set it on the top of the Vertical Plates.

Place the Top Plate (1) on top and align the holes with the Vertical Plates. Use the appropriate length 3/8-16 screws (5) to fasten the Top Plate to the Vertical Plates. If the holes do not line up exactly, loosen the M6 screws (4) and move the Vertical Plates.

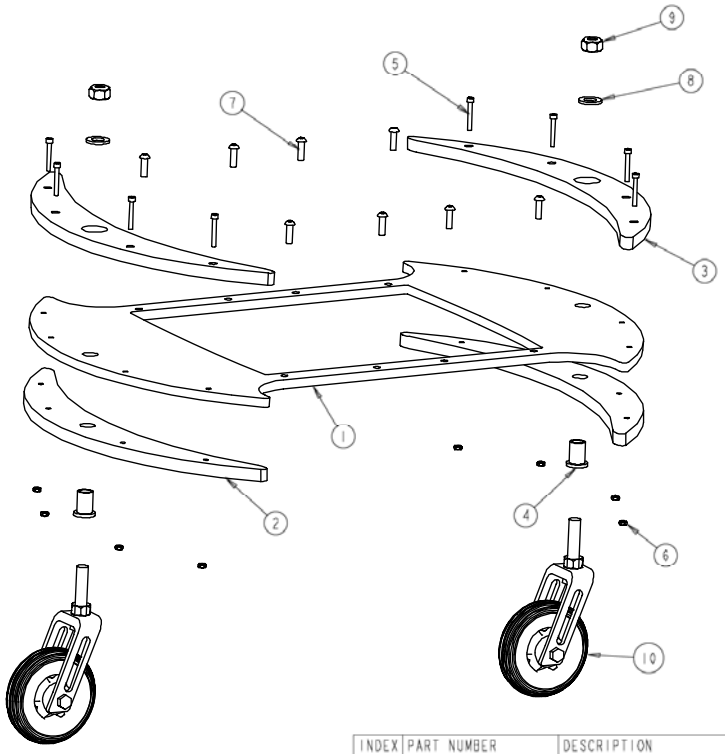
Snug down the 3/8-16 base plate screws then snug down the M6 screws. Next, torque the Top Plate screws to 54 N-m (40 ft-lbs) and the M6 screws to 18 N-m (13.5 ft-lbs).



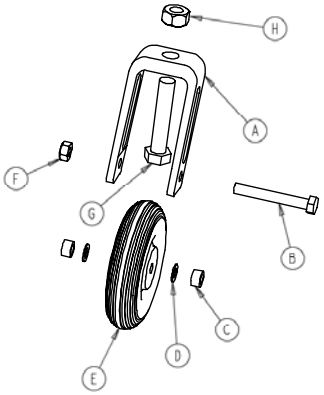
Item	Qty.	Part Number	Description	Comments
1	1	17941-00001	RMP Top Plate	
2	1	17507-00001	RMP Ballast Plate	
3	2	17506-00001	RMP Vertical Plate	
4	6	17512-00001	M6x1x25 SHCS	Tighten to 18 N-m (13.ft-lb)
5	4	17510-00001	3/8-16x1.25 SHCS	Tighten to 54 N-m (40 ft-lb)

RMP50

The RMP50 is shipped fully assembled and ready for use. An exploded view of the RMP50 frame is supplied should disassembly be required.



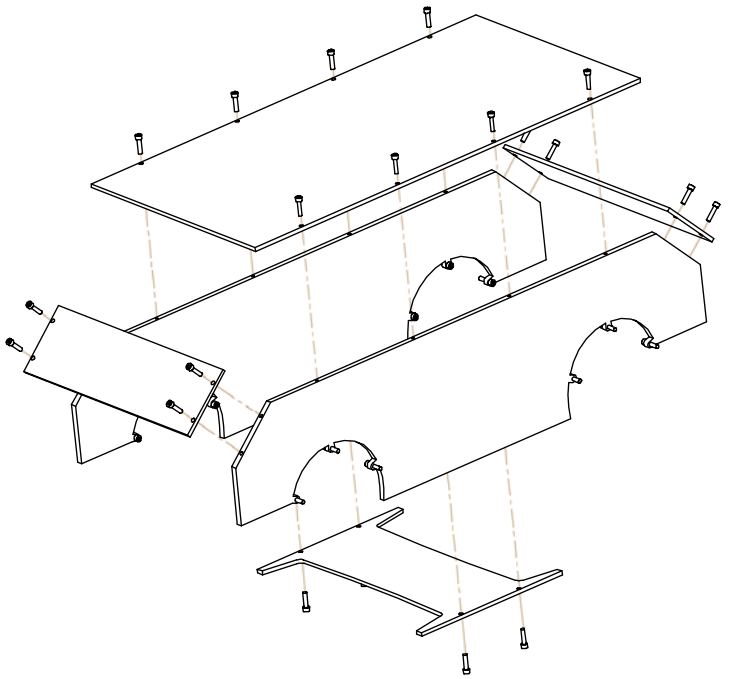
INDEX	PART NUMBER	DESCRIPTION	QTY
1	19464-00001.PRT	BUMPER PLATE, RMP 50	1
2	19462-00001.PRT	BOTTOM BUMPER, RMP 50	2
3	19463-00001.PRT	TOP BUMPER, RMP 50	2
4	20025-00001.PRT	BUSHING	2
5	20026-00001.PRT	M4X30 SHCS	8
6	20027-00001.PRT	M4 NUT	8
7	20028-00001.PRT	M6X20 BHCS	8
8	20029-00001.PRT	M12 WASHER	2
9	20030-00001.PRT	M12 NUT, VYNIL RING	2
10	20039-00001.ASM	ASM, CASTER, RMP 50	2



INDEX	PART NUMBER	DESCRIPTION	QTY
A	20031-00001.PRT	3" CASTER FORK	1
B	20033-00001.PRT	M8X70 BOLT	1
C	20034-00001.PRT	SPACER	2
D	20032-00001.PRT	M8 WASHER	2
E	20038-00001.PRT	4" X 1" CASTER	1
F	20035-00001.PRT	M8 NUT, VYNIL RING	1
G	20036-00001.PRT	M12X60 BOLT	1
H	20037-00001.PRT	M12 NUT	1

RMP400

The RMP400 is shipped fully assembled and ready for use. An exploded view of the RMP400 frame is supplied should disassembly be required.



INDEX	PART NUMBER	DESCRIPTION	QTY
1	20175-00001.PRT	SIDE PLATE, RMP 400	2
2	20176-00001.PRT	END PLATE, RMP 400	2
3	20177-00001.PRT	TOP PLATE, RMP 400	1
4	20178-00001.PRT	BOTTOM PLATE, RMP 400	1
5	1751200001.PRT	M6X1X25 SHCS	32

Theory of Operation: Balancing Dynamics

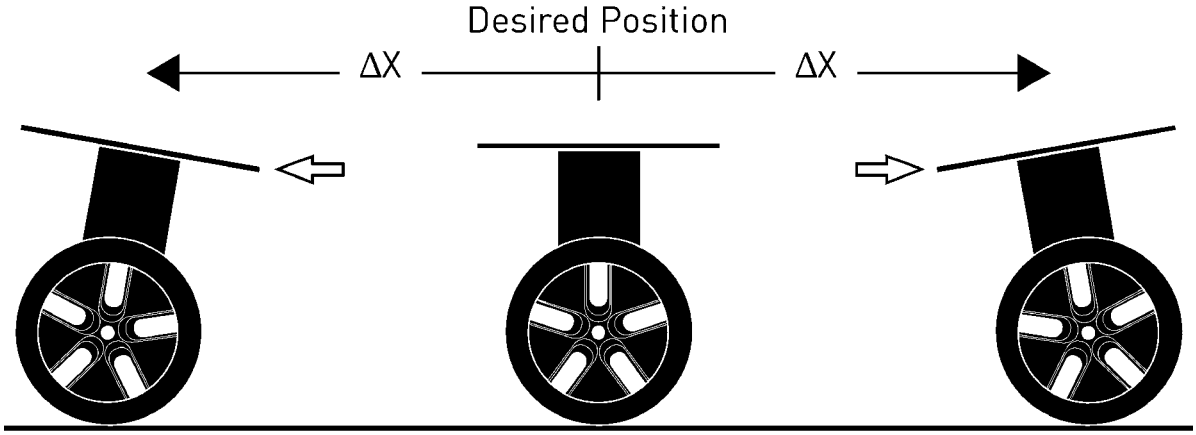
Read and understand this section before starting and operating the RMP. This information is critical to understanding RMP operation.

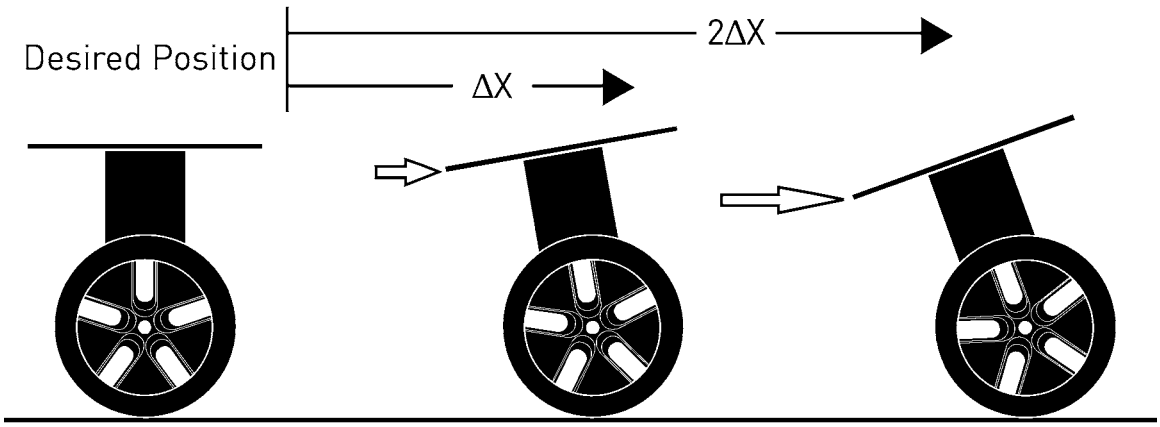
The Segway Robotic Mobility Platform is a dynamically stabilized machine and has some unique characteristics when compared to other robotic platforms. It may take some time to learn to use these dynamics to advantage. Read and understand this entire manual before using the Segway RMP.

Interaction With The Environment

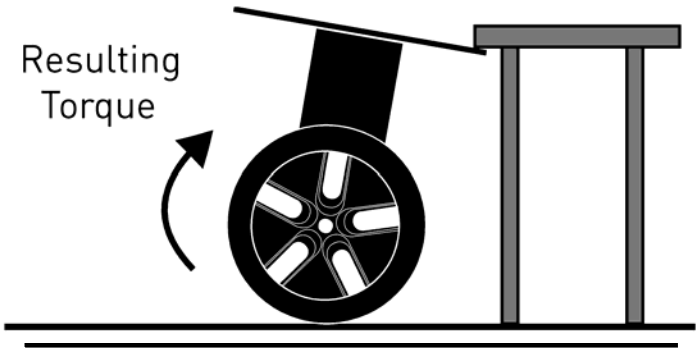
When the RMP makes contact with other objects in the environment, the results can be counter-intuitive at first.

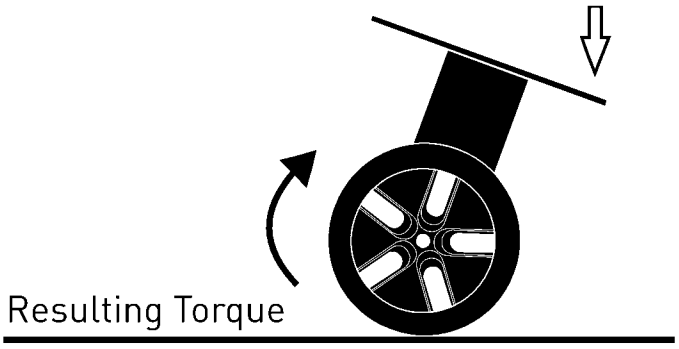
If the RMP is displaced from its desired position, it will lean against the displacement force, creating a new equilibrium position. The harder it is pushed, the more it will lean.





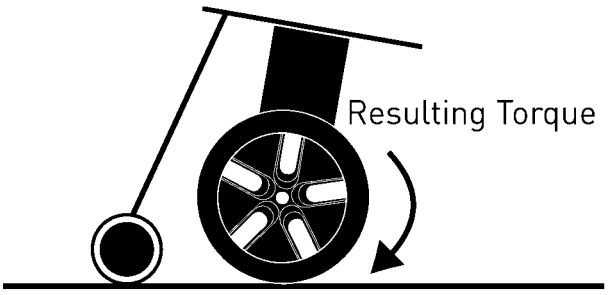
Consider the situation depicted at the right. The resulting torque will try to drive the machine to the right in order to reach a level orientation. If the wheels and frame are free to rotate, equilibrium will be achieved.

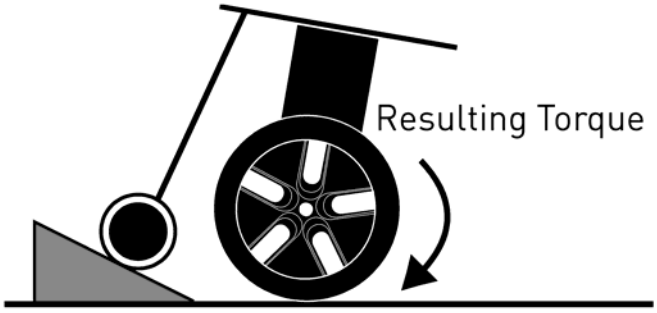




Pushing down on the right edge of the RMP will cause the machine to move to the right.

The case shown to the right is very different from a dynamic standpoint, but the controller cannot differentiate between this configuration and the one above. In this case, the RMP will accelerate faster and faster to the right trying to bring the machine to level equilibrium. It will quickly trip the position error limit of 12 feet and switch to tractor mode.

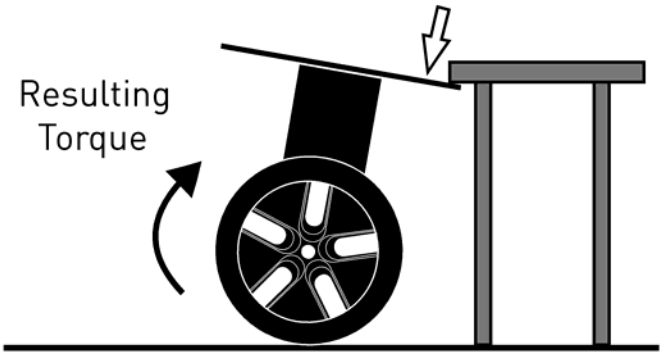




This case also results in rapid acceleration to the right until the RMP can level itself.

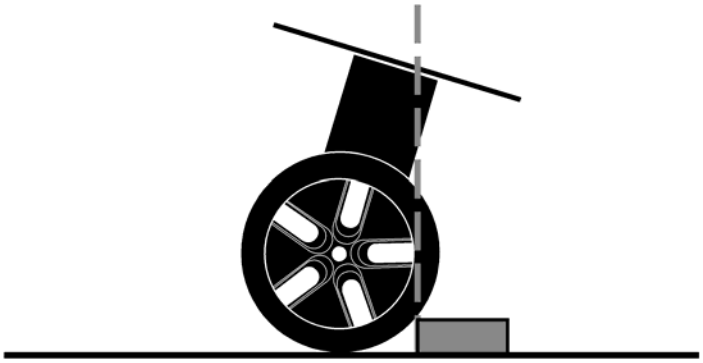
If the RMP is driven so that it gets one edge caught under a

surface (e.g. a counter or table), the resulting torque is also to the right. In this case, for the RMP to drive to the left on its own, the edge under the table must raise up to tilt to the left. This will lift up on the table.



To get the RMP unstuck, an external force must be applied to push the RMP's right edge down, forcing the wheels to the left. If a simultaneous command to drive the RMP back is also applied, the force required will diminish. Alternatively, use the E-Stop to disable the motors.

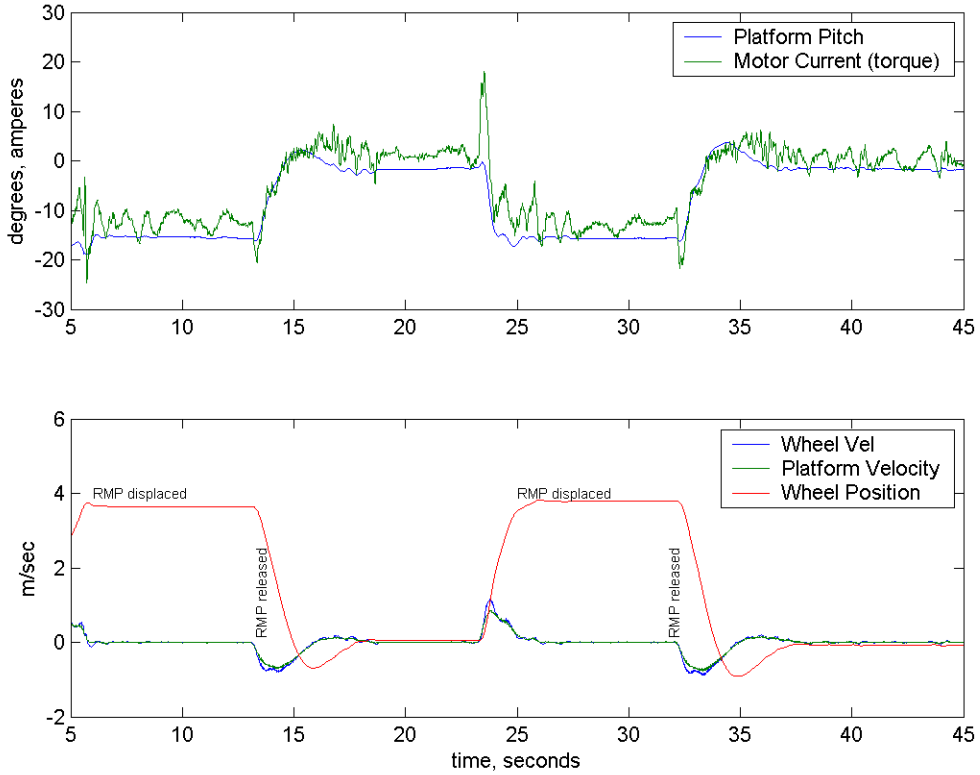
When the RMP needs to roll over an obstacle, the CG of the system must tilt forward over the contact point. When the tire makes contact with the obstacle, it stops rolling and the frame tilts forward. Once the CG is over the contact point with the obstacle, the RMP will roll over the obstacle (provided the obstacle is small and sufficient traction exists). Because torque is required to hold this tilted position, there is a tendency to overshoot the obstacle. Approaching obstacles with a small initial velocity typically helps in traversing obstacles.



Fore/Aft Motion

The following graphs show what happens when the RMP is displaced from a resting position. Pay attention to the following behaviors.

- The torque applied by the wheels is non-zero when the RMP is displaced from equilibrium – it is trying to return to its start location
- It will overshoot the desired pitch and position a little before coming to rest
- The wheels travel faster (and farther) than the top plate during this oscillation
- The response will vary slightly depending on the payload and the controller gain schedule used.

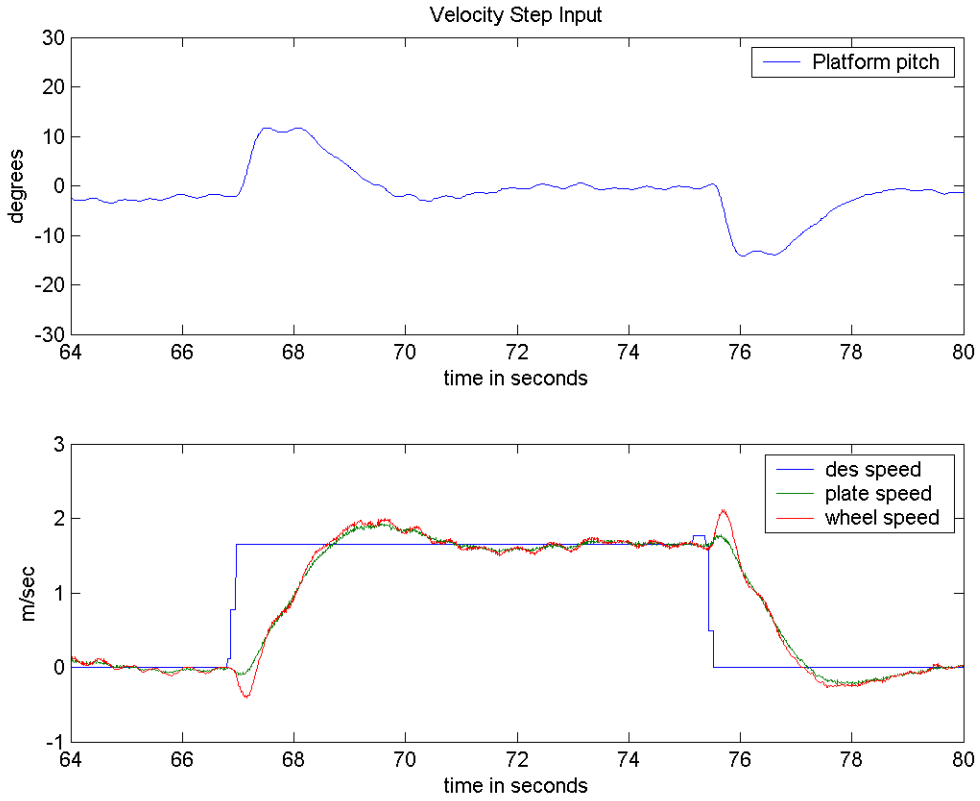


This figure shows the response of the RMP when it is displaced and released from an equilibrium position. The velocity command is zero throughout.

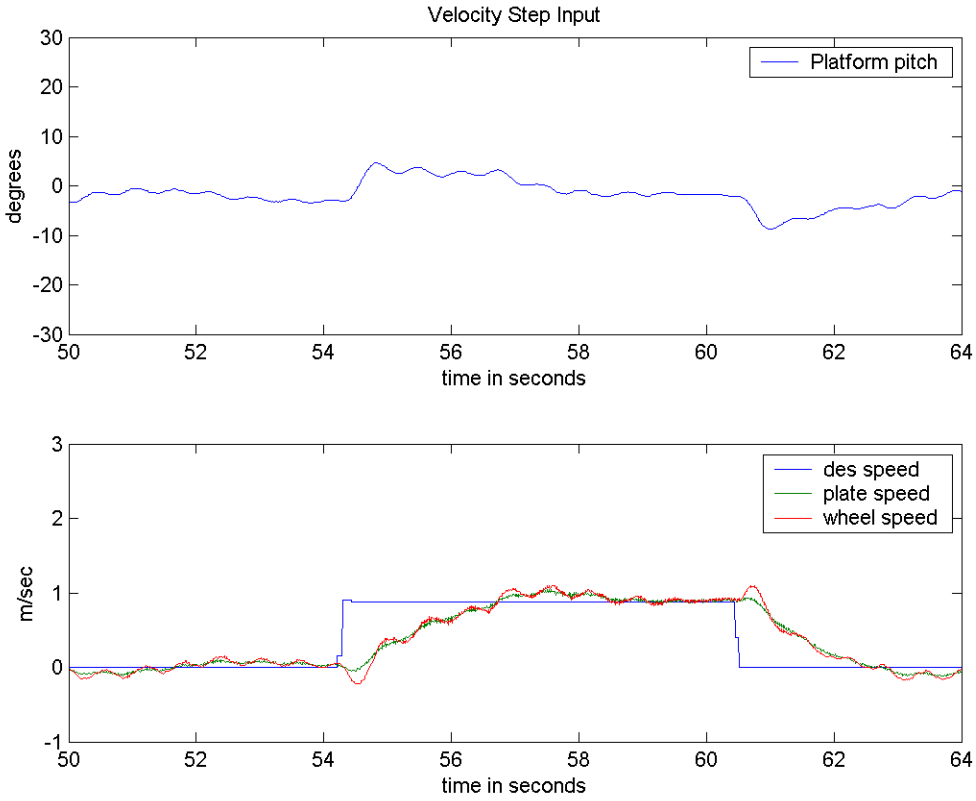
Velocity Commands

The next series of graphs show how the RMP accelerates in response to a desired velocity command. Note the following features in the data:

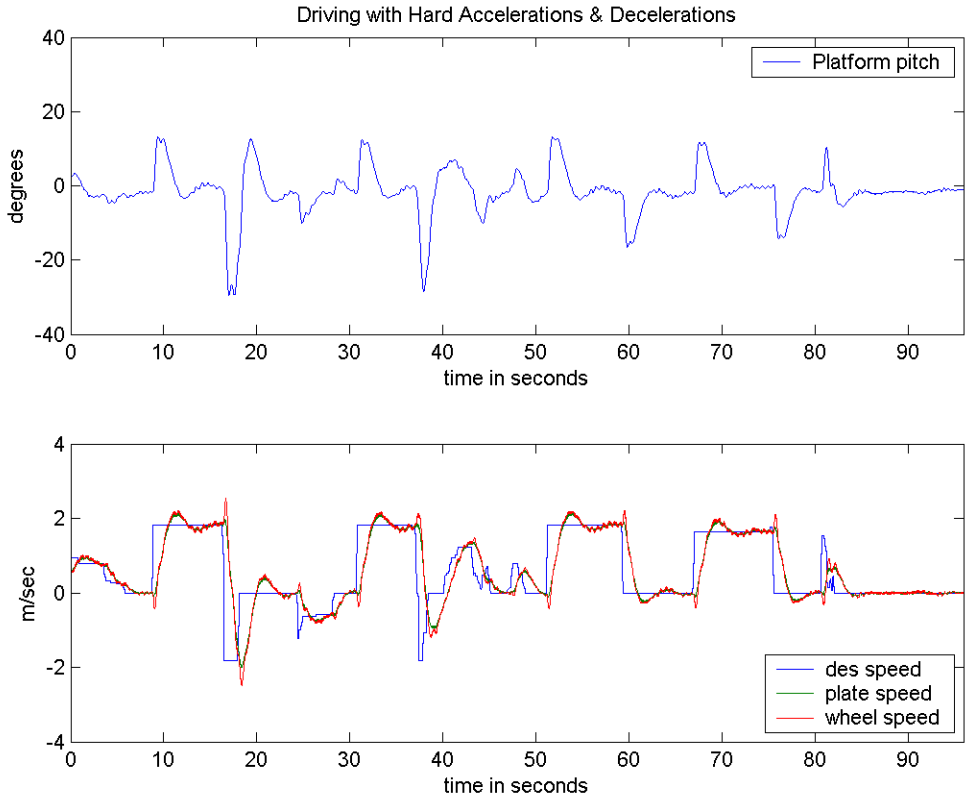
- The wheels move back slightly at the start of a forward acceleration, creating a delay
- The wheel speed overshoots the desired speed in order to stop accelerating and maintain constant speed
- The tilt angle of the RMP is a direct function of the acceleration limit – lower acceleration rates produce less tilt.



This figure shows the response of the RMP to a step input in the velocity command. The commanded speed is 4 mph or 1.77 m/sec. The Acceleration scale factor was set to 50% of maximum (8 counts)



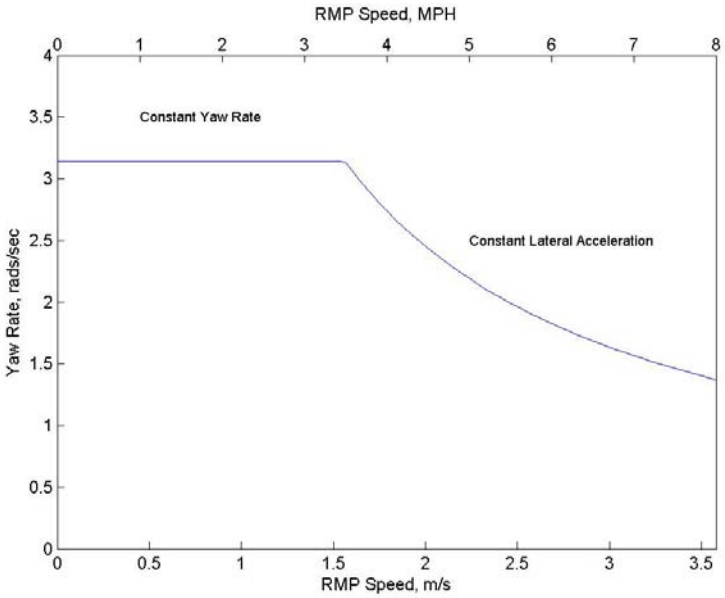
This figure shows the response of the RMP to a step input in the velocity command. The commanded speed is 2 mph or 0.88 m/sec. The Acceleration scale factor was set to 25% of maximum (4 counts)



This figure shows the response of the RMP to a series of step inputs in the velocity command. The commanded speed is 4 mph or 1.77 m/sec. The Acceleration scale factor was set to 50% of maximum (8 counts). Note the variations in pitch when the command is reversed from full forward to full reverse – a "hard stop" condition.

Turning

The Segway RMP uses a simple algorithm to control turning – the right and left wheels are driven at different speeds. The commanded yaw rate of the RMP is calculated in two ways. At low speed, the turning input is used to specify a rotation rate (e.g. radians per second). At higher speeds, the turning input specifies a lateral acceleration (e.g. m/sec^2 toward the center of the turn). The RMP speed is used to calculate the appropriate yaw rate to produce the commanded lateral acceleration. This provides better controllability at speed because it reduces the effective sensitivity of the turning input as the speed increases. The following figure depicts this effect graphically:



Configuration and Operation

Emergency-stop (E-stop) Function

The RMP provides an E-Stop switch that will cause the RMP to turn off if the switch is opened. The E-Stop function is activated when the red tether pulls the clip off the switch on the RMP User Interface. It is important to verify this functionality prior to using your RMP. The reasons are twofold:

- The E-stop function must work properly for your safety.
- Once the E-stop switch is opened, the RMP will no longer balance. You should become familiar with how it may fall so you can make good decisions when utilizing the E-stop.

The preferred method of attachment of the E-stop clip is a tether. This method allows an operator to activate the E-stop without having to make contact with the hardware, which may be moving at some speed.

Additional E-stop modalities such as a push button or remote controlled relay may be implemented in series with the delivered E-stop lanyard switch.

It is important to remember that a disabled RMP will fall over or roll freely.

Safety Shutdown Function

The Segway RMP has both redundant sensors and a redundant propulsion system that allow it to detect, isolate and operate during certain failures. The Segway RMP also monitors battery state of charge to ensure that enough power is available to balance the RMP. For many classes of faults, the Segway RMP will execute a “Safety Shutdown” if Balance Mode operation can not be ensured. This may occur due to a fault in the redundant system or a low battery. The Safety Shutdown consists of:

- Immediately bringing the RMP to a stop
- Annunciating with a loud, pulsing chatter that switches to a continuous tone after approximately 6-8 seconds
- Disabling motor power two seconds after the continuous tone starts

The annunciation alarm is to alert anyone in the vicinity that the RMP will be disabling power soon(and falling over unless some support is provided). The pulsing will increase in intensity and volume and then switch to a continuous tone two seconds before disabling the motors and turning off.

When the RMP is in Tractor Mode, a Safety Shutdown immediately disables the motor power.

The RMP maintains and reports certain status information that may be helpful in anticipating and responding to a Safety Shutdown. Consult the “Segway Robotic Mobility Platform Interface Guide” for a detailed interpretation of RMP data.

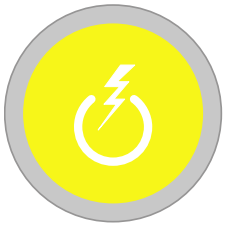
It is important to remember that a disabled RMP will fall over or roll freely.

Basic Operation

NOTE: The emergency-stop (E-stop) switch must be properly installed before attempting to power the RMP motors.

Startup

The RMP system starts up when the green power switch on the User Interface (UI) box is actuated. The green panel switch LED illuminates, indicating power is supplied to the UI. At this point the UI is able to send and receive USB and CAN messages.

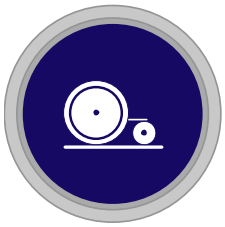


Motor Activation

The propulsion system motors are enabled by pressing the yellow start switch. This switch initiates the wake-up procedure for the Powerbase's CU boards. The yellow panel switch LED will illuminate along with the blue LED for Tractor Mode. The RMP always starts in Tractor Mode.

Tractor Mode

This mode is a non stabilized, differential steer driver mode. The wheel velocities may be commanded as either fore/aft motion or a turn rate. This mode may be useful for operators who do not wish to use the dynamic stabilization capabilities of the RMP. An additional ground contact must be provided by the operator (for example a castor wheel on a rigid bar).

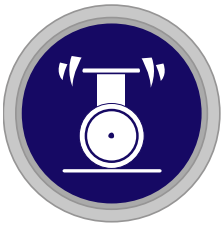


Balance Mode

Do not use Balance Mode with a third point of ground contact. See Balancing Dynamics section for explanation.

It is important that no obstacles be in the way of wheel motion when entering balance mode.

Never attempt to enter balance mode without frame attached.



Before entering Balance Mode, be sure the RMP is free to tilt 20 degrees forward and aft. Also make sure that the surface directly in front and behind the RMP is free of obstacles. To enter Balance Mode, hold the RMP approximately level and command balance mode one of two ways, by pressing the blue Balance Mode panel switch on the UI or through a Balance Mode command from the host computer. The blue Balance Mode panel switch on the UI will illuminate when the RMP is in Balance Mode.

Some movement may occur while the RMP finds equilibrium. Once Balance Mode is enabled you do not need to assist the RMP. At this point the RMP is able to balance itself and holding of the RMP by the user will inhibit this action and may produce unintended behavior.

Shutdown

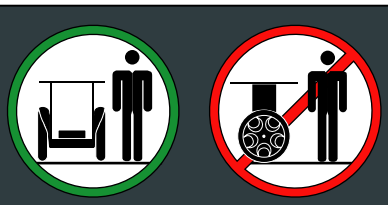
Pressing the yellow motor power switch on the UI turns off motor power to the system. The RMP motors will power down from either Balance Mode or Tractor Mode. The motors may also be turned off by command from the host processor to the UI. After motor power is off, press the green power switch on the UI to fully shut down the RMP. **Remember that the RMP will not balance when it is turned off.**

Learning about the RMP and Dynamic Balancing

Every new RMP user should perform the following experiments before attempting to drive it anywhere.

Read the section on Balancing Dynamics before attempting the following experiments.

Stand beside the RMP for these experiments (not in front or behind).



Use an open area away from objects and people.

Set the torque limit to 32 counts (max= 256).

1. Place a 10 lb object on the edge of the plate – the RMP will move to rebalance it self. Which way did it move?
2. Try pushing horizontally on the top plate – how does the top plate tilt in response to a horizontal disturbance force?
3. Push down gently on the front or back edge of the RMP – did it move as you expected? Did the top plate tilt the way you expected?
4. Lift up gently on the front or back edge of the RMP – did it move as you expected? Did the top plate tilt the way you expected?

Error Conditions

The Segway RMP may encounter certain environmental conditions that prevent balancing operation. Some of the more commonly encountered conditions are listed below.

Excessive pitch angle: If the RMP pitch angle exceeds 45 degrees forward or backward, it will disable power. This is because the RMP controller is unlikely to be able to restore balance once the machine has tilted past this angle.

Excessive roll angle: The RMP will disable power if the roll angle exceeds 60 degrees.

Excessive distance from commanded location: The RMP balance controller is designed to hold position based on several controller error terms. If the wheels on the RMP rotate too far from the original resting location (an equivalent of 12 feet of displacement) the RMP will disable Balance Mode and switch to Tractor Mode. This condition may occur if the wheels are slipping, a disturbance force pushes the RMP away from the equilibrium position, or some other condition is preventing the controller from reaching its equilibrium point (e.g. the machine is lifted off the ground).

Electrical Frame Fault: The RMP has been designed with a redundant propulsion system. These systems maintain electrical isolation in order to preserve capability in the event of certain failures. If an electrical connection is made between the two systems, the RMP will perform a safety shutdown. The most likely cause of this fault is connecting CAN channel ground to the frame of the machine. An optically isolated cable is required for any CAN-based communication architecture.

The Segway RMP firmware may be updated from time to time. Refer to the “Segway Robotic Mobility Platform Interface Guide” for detailed information regarding error conditions.

Tire Pressure

The tires should be inflated according to the following guidelines:

Payload	RMP200	RMP50 RMP100	RMP400 RMP200ATV
25lb	4-8 psi (0.27 – 0.55 bar)	10-15 psi (0.69 – 1.03 bar)	2-6 psi (0.13 – 0.77 bar)
50lb	4-8 psi (0.27 – 0.55 bar)	12-18 psi (0.83 – 1.24 bar)	
100lb	8-12 psi (0.55 - 0.83 bar)	15-20 psi (1.03 – 1.38 bar)	
200lb	10-15 psi (0.69 – 1.03 bar)	Not Recommended	

Operators may modify tire pressure based on their individual environments. In general, lower pressures increase traction and roll damping. Higher pressures increase range and roll stiffness.

RMP Configuration Parameters

General Guidelines for Payload Management

The software interface for the RMP provides the capability to switch between three balance controllers. Each controller has been optimized for a particular payload at a particular height. For best performance, the operator should endeavor to combine the ballast plate and the payload to reproduce mass properties that are close to the configurations identified in the Controller Gain Schedules section. (Ballast plates should be bolted underneath the top plate.)

In general, all 3 controllers will operate with a wide range of payloads. Choosing the controller that best fits your payload has one main advantage – namely the handling and dynamics of the control loop will be better damped and more predictable. The payload configuration is different for the RMP 100 and 200; refer to the appropriate part of the Controller Gain Schedules section for your RMP.

While each of the three controllers can balance a wide variation in payload, the degree of oscillation and control activity will change as the payload is altered. For example, both the "Heavy" (gain schedule 2) and "Light" (gain schedule 0) controllers can handle a 75 lb payload on the top plate, but the response of each controller will be slightly different in the presence of disturbances. For the RMP 200, the "Tall" (gain schedule 1) payload configuration will NOT balance with the "Light" or "Heavy" controller.

There is no provision for altering the controller gains in a continuous manner.

The controller gains are assigned when Balance Mode is enabled. Thus, it is necessary to send the gain schedule selection in Tractor Mode prior to entering Balance Mode. Changes to the gain schedule selection made while operating in Balance Mode will not take effect unless the RMP is switched to Tractor Mode and then back to Balance Mode.

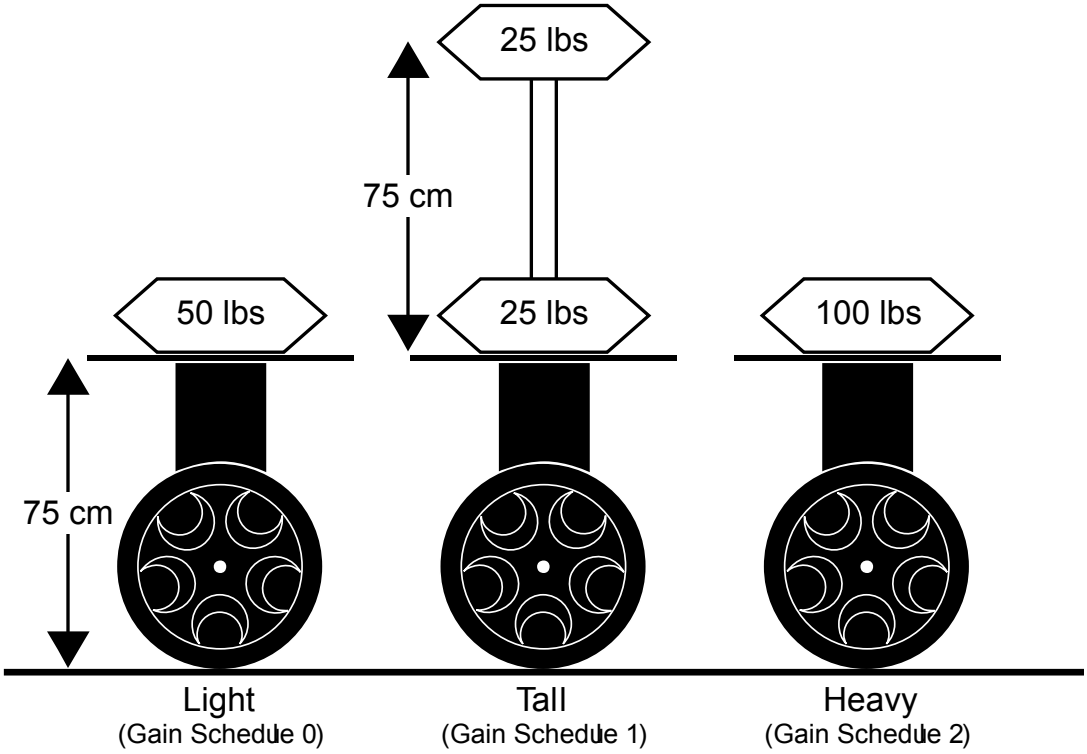
Controller Gain Schedules

There are three controller gain schedules for each model. These controllers have been optimized for particular payload configurations. The gain schedule used by the RMP may be changed by a command from the host processor, refer to the "Segway Robotic Mobility Platform (RMP) Interface Guide" for more detailed information on generating this command.

If you plan to use a weight distribution that is not specified, test the controller stability with an expendable payload first.

RMP 200 Payload Configurations

Using the "Tall" configuration requires extra care –tilt angles as small as 10 degrees result in large relative displacements of the wheel and upper payload.



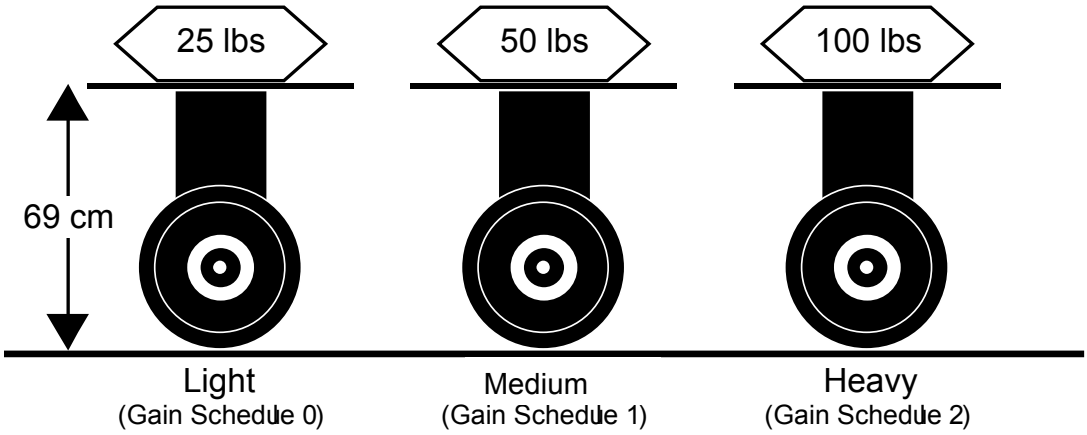
This figure depicts the three payload configurations that the RMP200 is designed to handle.

Controller Gain Schedule 0 – "Light"
This controller has been tuned for a 50 lb payload located at the top plate. This configuration may be created by using (2) of the 25 lb ballast plates. As payload is added, the Ballast Plates should be removed.

Controller Gain Schedule 1 – "Tall"
This controller has been tuned for a 25 lb payload located at the top plate and a 25 lb payload located 75 cm above the top plate.

Controller Gain Schedule 2 – "Heavy"
This controller has been tuned for a 100 lb payload located at the top plate.

RMP 100 Payload Configurations



This figure depicts the three payload configurations that the RMP200 is designed to handle.

Controller Gain Schedule 0 – "Light"
This controller has been tuned for a 25 lb payload located at the top plate. This configuration may be created by using (1) of the 25 lb ballast plates. As payload is added, the ballast plates should be removed.

Controller Gain Schedule 1 – "Medium"
This controller has been tuned for a 50 lb payload located at the top plate.

Controller Gain Schedule 2 – "Heavy"
This controller has been tuned for a 100 lb payload located at the top plate.

Scale Factors

Scale factors may be applied to the maximum velocity, maximum acceleration, maximum turn rate, and to the current limit. The scale factors limit the associated quantity to a fraction of its full scale value. Each of these scale factors may range from 0 to 1.0. Default values for these scale factors are:

Scale Factor	Default value	Parameter range
Maximum velocity	0.75	0.0 – 1.0
Maximum acceleration	0.75	0.0 – 1.0
Maximum turn rate	1.0	0.0 – 1.0
Motor Current (torque) limit	1.0	0.0 – 1.0

Scale factors are altered through commands from the host processor to the RMP; refer to the "Segway Robotic Mobility Platform (RMP) Interface Guide" for more detailed information on generating these commands.

Acceleration/Velocity Scale Factors

The acceleration scale factor provided by the software interface allows for very aggressive stopping and starting. Attempting to drive full reverse from maximum forward speed may command so much platform tilt that the device falls over. In an emergency stop, this may be preferred to continuing forward (much like a person who decides to fall back and slide when attempting to stop quickly).

The minimum stopping distance may be calculated from the maximum velocity, V_{max}, and maximum acceleration, a_{max}:

$$D_{\min} = \frac{V_{\max}^{\ 2}}{2a_{\max}}$$

Thus, large velocities with small accelerations produce large stopping distances. Choose your acceleration limits with care, considering both the need to stop quickly and the top speed you have chosen.

Turning Scale Factor

A turning scale factor parameter may be used to limit the maximum lateral acceleration of the RMP. This may be particularly useful with tall payloads, to prevent the RMP from tipping. In most cases though, higher turning sensitivity is useful for navigating around obstacles.

Motor Current Limit (Motor Torque) Scale Factor

The available wheel torque may be limited by reducing the motor current limit scale factor. Each wheel is capable of producing peak torque of 122 Newton-meters (90 foot-pounds). Setting the motor current limit to 1.0 (256 counts) results in full torque capacity; setting it to 0.0 (0 counts) results in no available torque. Dynamic balancing requires higher transient torque to accelerate, decelerate and traverse small obstacles. However, the torque required depends on the environment, task, and payload. Reducing available torque may be prudent in some cases. In Balance mode, limiting the torque too much will result in the RMP falling over during a transient. If in doubt, test the RMP performance using a robust payload that can tip over without being damaged.

Battery Packs

Safety Guidelines

Follow the instructions in this manual carefully for your own safety, the safety of others, and to maximize battery life and performance.

Related Documents

The information in this chapter provides a basic understanding of Segway RMP Battery Packs. For more advanced information on Nickel Metal Hydride (NiMH) Battery Packs read the complementary document, “Battery Care Booklet” posted at www.segway.com/support/docs.

Transportation and Shipping

If you are transporting your Segway RMP, protect the Battery Packs to avoid damage during shipment. Do not expose the Battery Pack to direct heat or moisture, and avoid heavy vibration during transportation.

Damaged Battery Packs

If the casing of a Battery Pack breaks open, leaks any substance, becomes excessively hot, or if you detect an unusual odor, do not use or transport the Battery Pack. Do not handle a damaged or leaking Battery Pack unless you are wearing disposable rubber gloves, eye protection, and are in a well-ventilated area. Dispose of the rubber gloves and damaged Battery Pack properly in accordance with regulations governing disposal of toxic materials.

Shipping Li-ion Battery Packs (on or off your Segway RMP)

Li-ion Battery Packs are considered "Hazardous Materials" under shipping regulations.
You may ship your Segway RMP by ground or sea with Li ion Battery Packs installed. You cannot ship your Segway RMP by air with Li-ion Battery Packs installed. You cannot ship your Li-ion Battery Packs separately from your Segway RMP by any means of transport. If you need to arrange air shipment of your Segway RMP with Li-ion Battery Packs installed, or if you need to arrange shipment of your Li-ion Battery Packs separate from the Segway RMP by any means of transport, contact a shipper certified in the regulations and procedures for shipping of “Hazardous Materials”.

	Ground	Sea	Air
Battery Packs Installed	Allowed	Allowed	Not Allowed “Hazardous Materials” regulations apply *
Battery Packs Not Installed	Not Allowed “Hazardous Materials” regulations apply *		

* Contact a shipper certified in the regulations and procedures for shipping of “Hazardous Materials”.

General Battery Cautions

Do not use the Battery Pack if the Battery Pack casing is broken or if a Battery Pack emits an unusual odor or excessive heat or leaks any substance.

Avoid contact with any substance seeping from the Battery Pack.

Keep out of reach of children and pets.

Exposure to Battery Pack voltage could result in death or serious injury.

Unplug and disconnect your Segway RMP from AC power before removing or installing Battery Packs or performing any service. It is hazardous to work on any part of your Segway RMP when it is plugged into AC power. You risk serious bodily injury from electric shock as well as damage to your Segway RMP.

The cells within the Battery Packs contain toxic substances.

Do not attempt to open Battery Packs.

Do not insert any object into the Battery Packs or use any device to pry at the Battery Pack casing.

If you insert an object into any of the Battery Packs' ports or openings you could suffer electric shock, injury, burns, or cause a fire.

Attempting to open the Battery Pack casing will damage the casing and could release toxic and harmful substances.

Charging

In order to maintain the best performance from your Segway RMP Battery Packs, fully charge your Battery Packs for at least twelve hours, once a month, or once every twelve hours of operation— whichever comes first. Make sure that your Battery Packs are within the specified charging temperature range when charging. Even if you do not intend to immediately use your new Segway RMP, you should still charge the Battery Packs for at least twelve hours as soon as possible.

1. Make sure the Charge Port is dry. Do not insert the plug if it is wet.
2. Plug the blue end of the Power Cord (provided with your Segway RMP) into the Charge Port on the RMP User Interface enclosure.
3. Plug the other end of the Power Cord into a grounded AC outlet (100 V to 240 V; 50 Hz to 60 Hz). The Power Cord should be properly grounded.

Remember to charge your Segway RMP whenever it is not in use. You do not need to worry about overcharging, so you should always plug your Segway RMP into AC power when it is not in use. Even if you will not be using your Segway RMP for an extended period of time, you should leave it plugged into AC power. Otherwise, the Battery Packs could fully discharge over time, causing them permanent damage. Do not store your Segway RMP or Battery Packs for more than one month without fully charging the Battery Packs at least once every thirty days. This could cause permanent damage to the Battery Packs.

Before Each Use—Remember to Close the Charge Port Cover

Close the Charge Port Cover except when you are charging the Segway RMP. Closing the Charge Port Cover will prevent water, dirt, dust, and other contaminates from entering through the Charge Port and causing damage to your Segway RMP.

Limit NiMH Battery Pack Discharge for the First Five Uses

To maximize NiMH Battery Pack life and performance, follow this procedure to charge and condition your new NiMH Battery Packs before the first use and after the first five uses:

1. **As soon as possible and before your first use, charge the Battery Packs for at least twelve hours.**
2. Limit the duration of the first five uses of your Segway RMP so that you do not excessively discharge the NiMH Battery Packs. (72 volts for RMP200, 57 volts for RMP50).
3. After each of your first five uses, charge the Battery Packs for at least eight hours.

Charge Indicators

The User Interface has two LED (Light Emitting Diode) charging indicators located above the Charge Port. The left charging indicator corresponds to the front Battery Pack, the right to the rear Battery Pack. They are marked “FRONT” and “REAR,” respectively. The charging indicators provide independent information regarding whether each Battery Pack is charging. When a green LED is on, the respective Battery Pack is receiving a pulse of current. Slow pulse rates are slow charging rates, faster rates denote faster charging, and solid green is the maximum charge rate.

Stage	Li-ion Battery Packs	NiMH Battery Packs
Initial Test	Battery Packs immediately proceed to “Fast Charge.”	Slow green pulse. Lasts for approximately 2 minutes.
Fast Charge	Solid green LEDs. The majority of charging takes place during this stage.	Solid green LEDs. The majority of charging takes place during this stage.
Cell Balancing	Green pulse; slows down over time. Lasts a few minutes to several hours, depending on how much balancing the cells require.	Fast green pulse. Lasts approximately 3 hours.
Fully Charged	LEDs are unlit for approximately 5 minutes	Battery Packs immediately proceed to “Battery Maintenance” stage.
Battery Maintenance	Several fast green pulses every few seconds.	Slow green pulse.

Charging Failures

If a failure is detected during charging, all charging will stop. Depending on the nature of the failure, a solid red charging indicator light will be displayed or the charging indicator will be off. (For Li-ion Battery Packs, the charging indicators will be unlit for approximately 5 minutes after the Cell Balancing stage.) If either or both charging indicators are off or red, do this:

- If the charging indicators are off (no illumination), check to make sure that AC power is present.
- If AC power is present and the charging indicators are either red or off, unplug the power cord, then remove and reseat the Battery Pack(s).
- If this does not resolve the problem, contact Segway, www.segway.com.

NiMH Battery Packs are Particularly Sensitive to Proper Charging Temperatures

If your NiMH Battery Pack is too hot or too cold, the charging indicator will continue to blink, indicating a slow or trickle charge, until the battery temperature is within the charging temperature range. Once stabilized within this range, the fast charge will begin and the charging indicator will be solid green. If the charging indicator lights remain blinking throughout the entire time that the Segway RMP is plugged in, then the Battery Packs have tricklecharged the entire time. This will provide only a small amount of energy into the Battery Packs. If you are concerned that the NiMH Battery Packs are too hot or too cold during charging:

- Check the charging indicators to make sure they show solid green, indicating fast charge.
- If the charging indicators do not show solid green within 15 minutes after the Segway RMP is plugged in, move the Segway RMP to a location within the recommended charging temperature range.
- After the Battery Packs are within the recommended temperature range, reconnect the Power Cord.
- If the charging indicators still do not show solid green within 15 minutes, contact Segway.

In hot conditions, you can improve charging by:

- Moving the Segway RMP or off board charging unit out of the sun, or off of hot asphalt (into an air-conditioned environment is best).
- Placing a fan near the Segway RMP or off board charging unit to blow air over the batteries.

General Battery Information

Regenerative Braking

The Segway RMP has a regenerative braking system that charges the Battery Packs when descending a hill or slowing down, or when you push or pull the Segway RMP while in Tractor Mode. When driving downhill, you may notice an increase in the battery charge level. If your Battery Packs are already completely full at the top of a hill, when you descend, a speed limit may be enforced to prevent overcharging.

Surface Charge

Whenever you do not fully charge the Segway RMP's Battery Packs (or most batteries, for that matter), there is a possibility of surface charge affecting the correlation between voltage and stored energy. After you power on, check the battery voltage level, then operate for at least three or four minutes and check the battery voltage level again. If the battery voltage level drops quickly during these three or four minutes, you should conclude that the Battery Packs had only a surface charge. If required, plug the Segway RMP back in and recharge.

Temperature Affects Performance

The Battery Packs will generally be significantly warmer than the air temperature due to heating that occurs as electricity is delivered from them (while operating) and to them (while charging.)

Operating in Hot or Cold Temperatures

The Battery Packs will run at the highest capacity when you operate them nearest the center of the recommended operating temperature range. If the Battery Packs on your Segway RMP become too hot or too cold while operating, the Segway RMP may reduce the speed limit or perform Safety Shutdown. As with all batteries, less energy is available at low battery temperatures. You may not be able to travel the same distance when the Battery Packs are cold, as when the Battery Packs are nearer to room temperature.

Charging in Hot or Cold Temperatures

Your Battery Packs should be within the recommended charging temperature range prior to and during charging. The Battery Packs will charge most efficiently when they are nearest the center of the recommended charging temperature range. If your Battery Packs are too hot or too cold, they may take longer to charge, or they may not charge at all. If you are concerned that the Battery Packs may be too cold or overheated during charging, refer to Charging Failures.

Replacing Battery Packs

Battery Packs should last the equivalent of 300 to 500 full charges. As your Battery Packs near the end of their useful life, they need more frequent charging and your Segway RMP's range will be reduced. To order replacement Battery Packs, contact Segway.

Use the Same Battery Pack Types

Your Segway RMP is powered by two rechargeable Battery Packs. Do not mix Battery Pack types. Always use Battery Packs in pairs of the same chemistry, for example, two NiMH or two Li-ion Battery Packs. If two Battery Packs of different chemistry type are installed on the same machine, you will be unable to operate your Segway RMP

Replace Battery Packs in Pairs

Whenever you replace a Battery Pack, consider replacing both Battery Packs, and always use pairs of Battery Packs with the same chemistry. Replacing only one Battery Pack will not necessarily increase the performance or range of your Segway RMP, because the Segway RMP is designed to operate only at the level allowed by the lower-energy Battery Pack. Redundancy is a critical safety feature built into the Segway RMP. This applies to the Battery Packs. Therefore, you should replace Battery Packs in pairs (except for the unusual situation where a Battery Pack is replaced because of damage or defect and the other Battery Pack is relatively new).

Service Operations

Remove the Battery Packs

Tool Required: 3 mm hex wrench.

1. Make sure the Segway RMP is powered off and not plugged in. It is unsafe to perform this procedure while the Segway RMP is powered on or charging.
2. Tip the Segway RMP onto its side so that the outside of one of the wheels lays flat against a clean, smooth surface. (Place a soft material under the wheel to reduce the chance of scratches.)
3. Use the 3 mm hex wrench to remove the fasteners (4 per Battery Pack).
4. Pull Battery Packs straight off chassis.

The cells within the Battery Packs contain toxic substances. Do not attempt to open Battery Packs. Do not use the Battery Pack if its casing is broken or if it emits an unusual odor or excessive heat or leaks any substance. Do not handle a damaged or leaking Battery Pack unless you are wearing disposable rubber gloves, eye protection, and are in a well-ventilated area. Dispose of rubber gloves and damaged Battery Pack properly in accordance with regulations governing disposal of toxic materials.

Reseat the Battery Packs

Tool Required: 3 mm hex wrench.

1. Make sure the Segway RMP is powered off and not plugged in. It is unsafe to perform this procedure while the Segway RMP is powered on or charging.
2. Reseat Battery Packs on chassis with curved edge facing outside of chassis.
3. Thread in the fasteners and tighten with the 3 mm hex wrench (4 per Battery Pack). To avoid risk of damage, do not use a power tool to thread in or tighten fasteners. Tightening Torque: 1.0 N-m (8.9 in-lb)

Remove Tire/Wheel Assembly

Tools Required: 16 mm deep socket wrench with 8" (20 cm) or longer wrench handle, rubber mallet.

1. Make sure the Segway RMP is powered off and not plugged in. It is unsafe to perform this procedure while the Segway RMP is powered on or charging.
2. Tip the Segway RMP onto its side so that the outside of one wheel lays flat against a clean, smooth surface. (The RMP100 and RMP50 wheel is dome-shaped and will not lay flat. Make sure to protect the Wheel from damage by placing it on a thick, soft surface.)
3. Remove the Wheel Nut with a 16 mm deep socket wrench. Hold the wheel from rotating and turn the wrench counterclockwise. (This may require considerable force.)
4. Strike the outside edge of the tire with a rubber mallet to unseat the wheel hub taper. (This may require multiple attempts as the wheel hub is seated tightly into the Gearbox taper.)
5. Lift off the wheel.
6. Clean any debris from outside of drive shaft and inside of wheel hub.

Reseat Tire/Wheel Assembly

Tools Required: 16 mm deep socket wrench with 8" (20 cm) or longer wrench handle.

1. Make sure the Segway HT is powered off and not plugged in. It is unsafe to perform this procedure while the Segway HT is powered on or charging.
2. Place the wheel hub opening over the Gearbox drive shaft; rotate the wheel while pressing down until the wheel seats.
3. Thread on the wheel nut and tighten with the socket wrench. Tightening Torque: 50.0 N-m (36.9 ft-lb)

Cleaning

Clean your Segway RMP with soap and water and a soft cloth. Do not use a power washer or high pressure hose because this could drive water into components that must stay dry. Avoid getting water in the Charge Port or the USB Port.

Do Not Open the Powerbase or Gearboxes

Do not attempt to open the Segway RMP Powerbase (sealed with T27 bolts and a steel cover plate). There are no user serviceable parts inside. By opening the Powerbase, you risk electric shock injury. Also, you could void your limited warranty, damage your Segway RMP, and render it unsafe to use. Do not attempt to open the Gearboxes. There are no user serviceable parts inside. You could damage your Segway RMP and render it unsafe to use.

Contact and legal information

Report All Incidents

If you or any other user of your Segway RMP is involved in an accident, or if your Segway RMP performs in a way that you do not intend or in a way that it is not supposed to, contact Segway Customer Operations by telephone at 1-866 4SEGWAY (1-866-4929), or by Email: technicalsupport@segway.com

How to Reach Us

Call Segway in the USA (English-language only) at +1-866-473-4929. Email Segway directly (English-language only) at technicalsupport@segway.com.

California Warning

This product contains chemicals, including lead, known to the State of California to cause cancer, birth defects or other reproductive harm.

Segway Inc. Patent and Licensing Information

The Segway RMP is covered by US and foreign patents, including one or more of the following:
US Patent numbers (issued): 5,701,965; 5,791,425; 5,794,730; 5,971,091; 5,975,225; 6,223,104; 6,288,505; 6,302,230; 6,332,103; 6,357,544; 6,367,817; 6,405,816; 6,408,240; 6,415,879; 6,435,535; 6,443,250; 6,538,411; 6,543,564; 6,553,271; 6,561,294; 6,571,892; 6,575,539;6,581,714; 6,598,941; 6,651,763; 6,651,766; 6,715,845; 6,779,621; 6,789,640; 6,796,396; 6,799,649; 6,815,929;6,827,163; D489,027; D489,029; D489,300; D493,127;

Foreign Patent Pending (published application serial number): AT: 95911624.5. AU: 62669/99; 21703/00; 37202/00; 37430/00; 37450/00; 33980/00; 54557/00; 53137/00; 80362/00. BE: 95911624.5. CA: 2,211,738; 2,346,442; 2,337,130; 2,363,737; 2,367,501; 2,375,313;2,366,076; 2,373,275; 2,375,645; 2,382,360; ,393,418;
2,401,488; 2,431,070. CH: 95911624.5. CN: 95197546.3;00812269.5; 95197546.3. DE: 95911624.5; 00916035.9. DK: 95911624.5. ES: 95911624.5. EP: 1123235; 1159686; 1161214; 1161215; 1161216; 1180996; 1181187; 1183163; 1208032; 1237779; 1259415; 1298041; 1324911. FI: 973197. FR: 95911624.5; 00916035.9. GB: 95911624.5; 00916035.9. GR: 95911624.5. HK: 02101085.2; 02106106.6; 02106105.7; 03105015.7; 02106266.2; 02108322.0. ID: W00200102875; W00200102136; W00200102823; W00200200009;
W00200200024; W00200200451; W00200201309. IE: 95911624.5; IL: 155,390. IN: IN/PCT/02/00280/CHE. IT: 95911624.5. JP: 8-523486; 2000-577062; 2001-508659; 2000-602941; 2000-604799; 2000-621191; 2000- 604801; 2001-501161; 2001-501493; 2001-519543; 2001-543388; 2001-563370; 2003-35305. KR: 10-2001-7016896; 10-2001-7011189; 10-2001-7015260; 10- 2001-7015490; 10-2001-7015564; 10-2002-7002673; 10-2002-7007338. MC: 95911624.5. MX: 2001/004018; PA/a/2001/012685; PA/a/2001/008933; PA/a/2001/ 009342; PA/a/2001/012232; PA/a/2001/009374; PA/a/ 2000/12498; PA/a/2001/012557; PA/a/2002/002217; PA/a/2002/005801; 000162. MY: PI20000540; PI20001210; PI200010118; PI20001458; PI20002479; PI20002502; PI200014753. NL: 95911624.5. NO: P973,153; 20011809.NZ: 513868; 517412; 525279. RU: 2000114547;2002108569. SE: 95911624.5. SG: 200201245-8;200203390-0. TW: 88117468; 89,106,673; 89,110,752.WO: 00/23315; 00/52588; 00/54719; 00/54720; 00/54721; 00/61426; 00/73101; 00/74623; 00/75001; 01/02920; 01/064502; /01/15962; 01/42077; 02/030730; 02/068219; 2003/103559; 03/105967; 2003/106250; 2004/007233; 2004/007264; 2004/075804; 2004/078603;2005/009828.

Additional unpublished patent applications are pending. Segway Inc. manufactures and sells Segway Robotic Mobility Platforms under a license from DEKA Products Limited Partnership.

Glossary

Balance Mode:	Dynamically stabilized operation of the RMP.
CAN:	Controller Area Network, a two-wire differential serial bus.
E-Stop:	Emergency stop. A switch that immediately disables the RMP.
Powerbase:	The portion of the Segway HT or RMP that includes the chassis, batteries, motors, gearboxes, and balance electronics.
Safety Shutdown:	A state that is activated if the RMP recognizes a fault in any of its systems. The RMP lets its operator know it is performing a safety shutdown by beeping, shaking, and slowing to a stop. A safety shutdown may also be triggered by low battery power. Once a safety shutdown has begun, the RMP will have approximately 10 seconds of operating time before shutting down and falling over (if in balance mode).
Tractor Mode:	Operation of the RMP without dynamic stabilization. The RMP must be stabilized by another point of contact to operate in Tractor mode without falling.
User Interface (UI):	Part of the RMP that communicates with the host computer and relays commands to the power base.
USB:	Universal Serial Bus.